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Mr. Frith and Professor Hennessy expressed a hope that Professor Galbraith would communicate the observations of temperature and barometric pressure made within the same period.

Mr. Yeates stated that his observations of rain-fall coincided very exactly with those of Professor Galbraith. In connexion with the fact of the minimum of monthly rain-fall occurring in February, he remarked that the annual minimum of temperature occurred, with remarkable regularity, in the middle of the same month.

The Rev. Samuel Haughton read a paper "On the Evaporation and Fall of Rain at St. Helena, Dublin, and Enniskillen, during the year 1860."

Dr. Sidney, Mr. Frith, and Mr. James Haughton made some observations on that part of Mr. Haughton's paper which referred to the water supply of the city of Dublin.

Professor Hennessy expressed a doubt as to the perfect accuracy of the method employed by Mr. Haughton to estimate the difference between rain-fall and evaporation.

Mr. Haughton briefly replied.

The Rev. Samuel Haughton, F. R. S., Fellow of Trinity College, Dublin, read a paper—

ON THE STORM OF THE 9TH OF FEBRUARY, 1861.

On the 11th instant I expressed to the Academy my opinion, that the disastrous storm of the 9th instant was not a Cyclone, and that its occurrence could not therefore be predicted from barometrical observations made in a single locality. Further inquiry into the circumstances of this storm shows that this opinion was correct, and that it constitutes an admirable example of Dove's second kind of storm, outside the limits of the Trade winds (Ueber das Gesetz der Stürme, p. 48.) In this class of storms, there is a direct opposition between the S. W., or equatorial current, and the N. E., or Polar current, of air; there is generally a succession of non-cyclonic gales, N. E. and S. W.; and when the S. W. wind gives place to the N. E., there is a rising barometer and minimum temperature corresponding to the time of the storm. The following facts place the peculiar and non-cyclonic character of this storm beyond all doubt.

Dublin.—In this city a wave of atmospheric pressure occurred, of 8 days, 4 hours' duration, the two crests of the wave being—

1st crest, Feb. $1^d\ 22^h$; Barom. = 30·70 in.
2nd crest, Feb., $10^d\ 2^h$; Barom. = 30·48 in.

And the hollow of the wave being—

Feb. $5^d\ 2^h$; Barom. = 29·00 in.

The gale or storm occurred of maximum violence,—

Feb. $9^d\ 22^h$, velocity 24 miles per hour.

The accompanying Table shows all the circumstances of the week preceding the storm :—

MAGNETICAL OBSERVATORY, TRINITY COLLEGE, 1861.

February.	Barometer, 1861.				Direction of Wind.			
	10 A. M.	1 P. M.	6 P. M.	10 P. M.	10 A. M.	1 P. M.	6 P. M.	10 P. M.
1, .	29·870	30·051	30·467	30·595	N. W.	N. W.	N. W.	W. N. W.
2, .	30·724	30·674	30·628	30·590	S. W.	S. W.	S. W.	S. W.
4, .	29·836	29·820	29·790	29·718	W. S. W.	W. S. W.	S. W.	S. S. W.
5, .	29·273	29·163	29·058	29·029	S.	S. S. W.	S. S. W.	S. S. W.
6, .	29·040	29·058	29·215	29·287	S. S. W.	S. W.	S. W.	S. W.
7, .	29·432	29·458	29·586	29·625	S. W.	W. S. W.	W.	W.
8, .	29·704	29·700	29·718	29·735	N.	N.	N. N. E.	N. N. E.
9,*.	29·982	30·048	30·228	30·316	N. N. E.	N. N. E.	N. E.	N. E.
11, .	30·180	30·087	29·990	29·929	N. E.	N. E.	E.	S. E.
12, .	29·707	29·670	29·610	29·585	N. E.	E. N. E.	S. E.	S. E.
13, .	29·738	29·781	29·879	29·932	S. E.	S. E.	S. E.	S. E.
14, .	29·880	29·745	29·669	29·602	S.	S. S. E.	S. S. E.	S. S. E.
15, .	29·425	29·363	29·333	29·377	S. S. E.	S. S. E.	S. S. E.	S. S. E.
16, .	29·563	29·531	29·533	29·541	S. W.	S. S. E.	S.	S.
18,†.	29·509	29·511	29·488	29·371	S. E.	S. E.	S. E.	S. E.
19, .	29·102	29·242	29·472	29·472	S.	S. W.	S.	S. S. E.
20, .	29·156	29·158	29·156	29·088	S. S. E.	S. S. W.	S.	S. S. E.
21,‡.	29·137	28·964	28·959	29·190	S.	S. E.	W.	S. S. W.
22, .	29·451	29·526	29·572	29·604	S. S. W.	S. S. W.		
23, .	29·740	29·758	29·896	29·982				
25, .	30·296	30·244						

From this Table it also appears that the equatorial wind (S. W.) continued from the 2nd of February, to the evening of the 7th of Feb., when it gave way to a West wind, then a North wind, and finally settled at 10, P. M., of the 8th, into a N. N. E. polar current, at which point it held throughout the storm, which reached its maximum twelve hours after the N. N. E. wind began to blow. On the night of the 9th of February it blew from the N. E., and so continued for 40 hours afterwards. The temperatnre, during the prevalence of the S. W. wind, and falling barometer, was mild, and the air damp, producing a feeling of closeness, from the vapour present in the air. For eight days previous to the minimum height of the barometer, the mean temperature was 49°·7; while during the three days following the minimum of the barometer, the mean temperatures were—

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* *Storm* at Dublin from N. N. E. Same point throughout. Velocity of wind, 24 miles per hour.

† *Gale* at Drogheda, Dublin, Dunmore East, and Penzance, from S. E. Same point throughout.

‡ *Storm* in London, Chichester, and Plymouth; gale in Dublin at midnight. At 7 P.M. in London the pressure was 36 lbs. per foot.

Wind in Dublin at same point throughout,—S. S. W.

Feb. 7, at 10 A. M., . .	42°·5	
„ 8, „ „ . .	40 ·8	
„ 9, „ „ . .	35 ·1	maximum of gale.
Mean, . .	39°·4	

This shows a rising barometer, a falling thermometer, reaching a *maximum* and *minimum*, respectively, at the time of the storm; and on the 8th and 9th of February heavy hail showers fell at intervals. Such a phenomenon cannot by possibility be confounded with a Cyclone, which has a *minimum* barometer just before, and in the middle of the storm, and no such relation of the gale to temperature as Dove has pointed out in the class of storms to which that of the 9th of February unquestionably belongs. The storm of the 9th was also only the first of a series, arising from the same cause, viz., the direct and non-cyclonic collision of the equatorial and polar currents of air.

I have drawn in Plate XI. the curve of Barometric Pressure at 10 A. M. and 10 P. M. for the week preceding the 9th of February, and also the curve of Temperature at 10 A. M. during the same period. These curves show at a glance that the storm occurred on the maximum of pressure and minimum of temperature; that the rising barometer occurred with a wind shifting from S.W. by W. and N. to N. E., and that the curve of temperature is inverse to the curve of pressure. Combining these facts with the fact that the wind continued for twenty hours in the N. N. E., and for twenty hours more in the N. E., the storm occurring during the first of those periods, I believe it impossible to suppose that any Cyclonic movement could account for such a combination of circumstances. The succession of gales from the 9th to the 21st of February was due to the Equinoctial gales arriving this year before their time, as is indicated by the high temperature and great moisture of the month, and by the excessive rain-fall, occasioned by the conflict of the polar and equatorial currents, unusual at so early a period in the year.

A *second* gale occurred on the night of the 18th, which was felt severely at Drogheda, Dunmore East, and Penzance, and caused the loss of several vessels; at all three places the wind blew steadily from the S. E.

A *third* storm has been reported from London, Chichester, Plymouth, and other places, on the evening of the 21st of February. It was felt in Dublin early on the morning of the 22nd, from the S. S. W., but not severely. At 7 P. M., in London, it was at its height, and is said to have reached 36 lbs. per foot; and it had sufficient force to blow down the spire of Chichester Cathedral.

According to Dove's theory, these two storms are supplements to the storm of the 9th, and not distinct cyclonic movements.

Limerick.—I have ascertained from a respected correspondent in this city, that the barometer was rising slowly and steadily on the 3rd and 4th; during the night of the 4th it rose rapidly, and on the morning of the 5th it was over 30·5 inches. On the evening of the 5th, it began to fall, and continued to do so until the 9th, when the storm occurred at Dublin, at which time the barometer in Limerick stood at 29 inches. There was no storm felt in Limerick. It thus appears that the atmospheric curve in Dublin was the inverse of that in Limerick; and that on the mornings of the 5th and 9th there was a difference of pressure in these cities of above one inch, in opposite directions. Although the barometer in Dublin or Limerick alone would not have enabled an observer to predict a storm, yet any person acquainted with the condition of the barometer at both places might fairly have expected rough weather from the N. E., such as actually occurred on the morning of the 9th of February, in Dublin.

Mr. Haughton then read to the Academy the following letter from Mr. Robert H. Scott:—

"13, *Suffolk-street, February* 22, 1861.

"DEAR MR. HAUGHTON,—I see by your remarks at the last Meeting of the Royal Irish Academy, that it is your opinion that the storm of the 9th instant could not have been predicted from observations of the barometer here in Dublin. I think, therefore, that it may interest you to compare the behaviour of the barometer and thermometer in the British Islands during the past month with the records of their behaviour throughout Europe in seasons similar to the present. You are aware that Professor Dove, in his Law of Storms (Berlin, 1857), whom I quoted in a letter to 'Saunders' News-Letter,' on the 12th, classifies all storms under three heads.

"I. Cyclones.—Arising within the zone of the trades from the interference of the return with the normal current.

"II. Gales.—Arising outside these limits, from the meeting of the two currents (equatorial and polar) blowing in directions opposite to each other.

"III. Gales arising from the lateral interference of these currents when they are, as is frequently the case, flowing in directions opposite to each other in parallel channels.

"The first class is fully treated of by the late General W. Reid. Cyclones are always preceded by a fall of the barometer; and the direction of the wind changes according to fixed laws during their continuance.

"The second class cannot be predicted by insulated observations at any one point, but requires a large amount of data obtained from localities scattered over a wide area of country. They are indicated by the co-existence of a high barometer and low thermometer over the eastern portion of that area, while to the westward the instruments show great rarefaction of the air, and a mild temperature. In this case there is usually a succession of alternating N. E. and S.W. gales, separated by some days from each other. *There is no rotation of the wind* during these storms.

"The third class is rare. It arises from the fact that when the polar and equatorial currents are flowing in parallel channels, the latter will assume a more westerly direction than the former does easterly, owing to their friction against the earth's surface. There will, therefore, if the equatorial current lie to the southward, be a partial vacuum in it, and a liability to a N. W. storm, during which the barometer will rise; or, if the polar current lie to the south there will be a cyclone generated in it.

"If you will allow me to quote two cases from Dove's 'Mean Temperature for every five days' (Fünftägige Mittel, Berlin, 1856), I think that you will see that I may be justified in referring the storm in question to Dove's second class. I shall take the winters of 1850 and 1855.

"The cold in the north of Europe in January, 1850, was very intense, and reached a maximum about the 20th of the month. This intensity was only felt at the stations situated at a low level, as the temperature at the Brocken, at an elevation of 3500 ft., was 28° F. above what it was at Heiligenstadt, twenty miles S. W. from that mountain. The barometer stood 9 lines above its mean level, along a line from Königsberg to Prague. On the same day there was a barometric minimum of 8·5 lines at North Salem in the state of New York. In this case we find the oscillations of the barometer, and the accompanying storms of wind and snow at Vienna. From the 19th, on which day there was a violent snow-storm, it rose 15 lines in two days, and the thermometer sunk to – 7°·6 F. On the 23rd the barometer fell again rapidly, and a N.N.W. storm, accompanied by a snow-fall of unusual magnitude ensued. In this case, we have at Vienna, lying on the line of contact of the two areas above referred to, a N.W. storm *preceded by a fall of the barometer.*

"On the other hand, E. storms, *accompanied by a rising* barometer, are recorded on two occasions in the winter of 1855–56.

"The autumn of 1855 was very warm and wet in the Mediterranean, while in the North of Germany it was marked by its extreme dryness, up to the end of October. In the middle of December the barometer rose to a great height over the whole of North Germany, the temperature sinking proportionably. From the 18th to the 21st a violent N. E. storm raged in the Black Sea, the Caledonia was lost at Sebastopol, and a fleet of ships were wrecked at the Sulina mouth of the Danube. Simultaneously with it there set in a violent S. E. storm in the British Channel, and on the south coast of Ireland, while the lowest temperature at Greenwich was felt on the 22nd. Hence we see that the polar current had gradually forced its way to the west. This barometric maximum was succeeded by a minimum on the 8th of January, 1856, at which time a violent N. E. storm was felt over the greater part of the United States. In Europe a second maximum occurred on the 13th, and its advent was marked by a N. E. storm and sudden fall of temperature on the lower Danube. After this violent S. W. gales set in on the south coast of France and Spain, and the fall of the barometer was the precursor of a long spell of warm weather.

"In the case of the present winter we have had here in Ireland a low barometer and very mild weather, while in England the frost continued with undiminished intensity. We were, therefore, as I think, in the position described by Professor Dove, p. 289 :—

"'Should the barometer oscillate, and yet the air remain at rest, the cause of the disturbance is at some distance. At times, in winter, the southerly current maintains its ground over a large area to such an extent that the air is delightfully mild, the barometer being low meanwhile. In this case there is somewhere in the neighbourhood a district where the barometer is high, and the weather very cold. *This cold air may then suddenly force its way into the rarefied air in its neighbourhood, as a storm, causing the barometer to rise rapidly.*'

"I need not say that these views are an attempt to represent the published opinions of Professor Dove, under whom I have studied ; and I cannot better conclude this letter than by giving you a confirmation of this theory which I have lately met with; it is from a paper by M. Spassky, entitled, 'Note sur la tempête d'hiver, &c., &c., entre le 9–11 Dec., 1850.' In explanation, I may say that there was on the 23rd of that month a barometric maximum in Europe, and a simultaneous minimum in America, followed by a violent snow-storm. This had been preceded by a minimum in Russia on the 6th, and a storm on the 9th. The narrative proceeds—'This storm lasted from thirty to forty-eight hours, between the 9th and 11th, without intermission. Before the gale it had been thawing; but the first gust caused the thermometer to fall 15° or 20° R. below Zero, so that persons who were out of doors fell dead, being lost in the driven snow, some close to their own doors. After the storm, 311 persons were found frozen to death in the Government of Kalonga, 140 in that of Tula, and 39 in the district of Kursk. It is probable that many more are as yet undiscovered, owing to the depth of snow. Houses were blown down, and even horses yoked to the sleighs were frozen to death. This atmospheric revolution was the result of the struggle between the two currents of air, by means of which Professor Dove's theory enables us to explain most atmospheric phenomena: and yet many physicists continue to dispute its truth, in the face of plain proofs like the above, which cannot be explained on any other hypothesis. In order to convince us that all the characteristic phenomena of the atmosphere were in exact accordance with Professor Dove's theory during this storm, we need only refer to the observations at Moscow. Before the 6th the Polar current prevailed there, N. wind, barometer 336·27 lines, and thermometer 14° 5 R. On the 6th the equatorial current appeared, barometer fell 15·53 lines before the 9th; the thermometer rose 12° 9, and the wind veered through S. to S. W. The polar current, having thus yielded to the first onset, collected its strength to force its opponent back. On the 9th there was a lull, followed by a north wind lasting up to the 11th, during which time the barometer rose 7·46 lines, and the thermometer fell 15° 4. On the evening of the 11th there was a fresh lull; and on the 12th the equatorial current set in again, as is shown by the wind getting round to S. W., the thermometer rising above Zero, and the barometer falling 6·06 lines.'

"Yours very sincerely,

"ROBERT H. SCOTT.

"*Rev. Professor Haughton.*"

PROFESSOR HENNESSY, F. R. S., read the following paper:—

ON CLAIRAUT'S THEOREM.

LAPLACE has shown that this theorem follows whatever may be the density of the interior parts of the earth, provided it consists of similar concentric strata, and that the form of the outer stratum is ellipsoidal. In the "Philosophical Transactions" for 1826, Mr. Airy (the present Astronomer Royal of England) has presented an equivalent result; more recently, Professor Stokes has shown that we can deduce the law of variation of terrestrial gravity without any hypothesis whatsoever as to the earth's interior structure. He assumes merely that its surface is spheroidal, and that the equation of fluid equilibrium holds good at that surface. In vol. vi. of the "Cambridge Mathematical Journal," Professor Haughton presented a demonstration, founded upon the same assumptions as those of Professor Stokes, and in which he uses certain propositions relative to attractions which had been enunciated by Gauss and Mac Cullagh. While studying the labours of those mathematicians, it appeared to me that the question could be entirely divested of the hydrostatical character, and that Clairaut's theorem may be directly deduced from the equations to the normal of any closed surface, without any considerations as to the physical condition of the matter forming that surface. Thus every surface concentric with the earth, and perpendicular to gravity, will possess the property of exhibiting this relation in the intensity of gravity at its various points.

Let X, Y, Z represent the components parallel to the rectangular axes of the forces by which a point is retained at rest on a given surface whose equation is $L = 0$. Then from the equations of the normal we have

$$Y\frac{dL}{dx} - X\frac{dL}{dy} = 0, \quad Z\frac{dL}{dx} - X\frac{dL}{dz} = 0,$$

when the resultant of these forces is perpendicular to the given surface. If we represent by V the potential of the earth on the particle in question, by w the angular velocity of rotation, we have

$$X = \frac{dV}{dx} + w^2x, \quad Y = \frac{dV}{dy} + w^2y, \quad Z = \frac{dV}{dx},$$